

REMARKS

Claims 1, 4-6, 9-11, 14-16, 19-21 and 25-51 are pending in the application. Claims 1, 4-6, 9-11, 14-16, 19-21 and 25-51 are rejected under 35 U.S.C. § 103 (a) as being allegedly unpatentable over U.S. Patent No. 5,699,440 (Carmeli) in view of Applicants' Admitted Prior Art and U.S. Patent No. 6,052,124 (Stein, *et. al.*, hereafter Stein). The Applicants amends independent Claims 1, 6, 11, 16, 21, 46, 49, and 50 to emphasize the inventive step of approximating a vignetting effect and an off-axis pixel projection effect from a pixel intensity drop off using a modeling equation. Support for these claim amendments are found throughout the Applicants' application as originally filed. (*See, e.g.*, Specification pages 5-8 and pages 11-12.). The rejections are respectfully overcome and reconsideration is requested. The Applicants adds no new subject matter.

Claim Rejections – 35 USC § 103

In the Office Action dated July 26, 2005, the Office rejects Claims 1, 4-6, 9-11, 14-16, 19-21 and 25-51 under 35 U.S.C § 103 as being allegedly unpatentable over “Carmeli...in view of applicants' admitted prior art and Stein...”. (*See* Office Action). The Applicants respectfully disagree and submit that the claimed invention is patentable over the cited references for at least for the following reasons.

Independent Claims 1, 6, 11, 16, 21, 46, 49 and 50, as now amended, relate to the use of camera defects that result in a pixel intensity drop off in a digitized image to recover intrinsic parameters (e.g., focal length) of a camera. The camera optical and physical shortcomings are used to extract the camera parameters. Due to camera defects, there is a pixel intensity drop off in the digitized image. This pixel intensity drop off is based on geometric and optical defects of the camera. The pixel intensity drop off is caused by a combination of a vignetting effect (a reduction in illumination of image points at the edge of the image (see equation 14 in the Applicants' specification)) which is geometric in nature (based on partial obstruction of light by the lens stop) and an off-axis illumination effect (illumination of the image point varies across the field of view in proportion to the fourth power of the cosine of the angle between the light ray and the optical path (*see* equation 5 in the Applicants' specification)) which is optical in nature. The intensity of a pixel (image point) in the digitized image is dependent on a

combination of these effects (geometric and optical). This dependency may be approximated using a modeling equation (see equation 15 of the Applicant's specification). Using this modeling equation, the vignetting effect and the off-axis illumination effect are approximated. Camera defects (optical and geometric in nature) are used to recover the intrinsic parameters. Thus, through the use of camera defects, the Applicants' claimed technique recovers a camera intrinsic parameter from a single image of a blank textureless surface, e.g., a blank sheet of white paper.

To establish a *prima facie* case for obviousness under 35 U.S.C. § 103 (a), (A) there must be some suggestion or motivation to combine reference teachings. (B) There must be a reasonable expectation of success. (C) The references when combined must teach or suggest all the claim limitations. For at least the reasons discussed below, it is respectfully submitted that the Office has not established a *prima facie* case under 35 U.S.C. § 103 (a) for Claims 1, 4-6, 9-11, 14-16, 19-21 and 25-51, and therefore, Claims 1, 4-6, 9-11, 14-16, 19-21 and 25-51 are allowable.

The Applicants' claimed invention is distinct from the Carmeli reference because 1) Carmeli does not describe approximating a vignetting effect and an off-axis pixel projection effect using a modeling equation, and 2) Carmeli in fact teaches away from approximating the vignetting effect and the pixel-projection effect using the modeling equation.

In regards to point 1, Carmeli's discussion of evaluating the effect of vignetting does not describe approximating a vignetting effect and an off-axis pixel projection effect using a modeling equation, as claimed by the Applicants, e.g., in amended Claim 1. In contrast, to accurately test the performance of the electro-optical system in terms of vignetting, the Carmeli reference describes analyzing a fall off of an output signal. (col. 11 ll. 14-15). Carmeli describes this fall off of the output signal as a lessening of an inputted uniform light function at its edges and corners. (col. 11 ll. 10-14). In this way, Carmeli evaluates the effect of vignetting by analyzing how much the inputted uniform light function is lessened at its edges and corners. To further illustrate this point, the Applicants refer to figures 10a and 10b of the Carmeli reference.

In figure 10a of the Carmeli reference, the inputted uniform light function has a value of 100 throughout, including at its edges and corners. Now referring to figure 10b of the Carmeli reference, owing to the effect of vignetting, the inputted uniform light function is lessened at its

edges and corners, e.g., the output signal has a value of 94 at its bottom right corner. In other words, the lessening of the uniform light function from the value of 100 to the value of 94 indicates a vignetting effect having a value of 6. To illustrate this point even further consider the following extended example.

Now suppose the uniform light function is halved, i.e., the inputted uniform light function now has a value of 50. Without changing anything else the outputted signal now has a value of 44 at its bottom right corner. The vignetting effect, however, still has a value of 6. In other words, in evaluating the effect of vignetting from the lessening of an inputted uniform light function, Carmeli concerns itself with the relative difference between the inputted signal and the outputted signal.

The Carmeli reference, however, does not describe approximating the vignetting effect by assuming that the surface properties of a flat textureless source object are constant throughout and can be approximated as a Lambertian source (i.e., a source for which luminance is independent of direction) and the illumination is constant throughout the surface of the source object, as taught by the claimed invention. In contrast, the Carmeli reference describes analyzing the output signal which is somewhat less than the input signal at its edges and corners (i.e., the fall off the output signal) to evaluate the effect of vignetting. (col. 11, ll. 12-14).

In regards to point 2, the Carmeli reference in fact discourages the claimed invention. The Carmeli reference does not describe nor suggest the desirability of providing reasonable estimates of camera parameters which may be used for applications which may not need accurate camera parameters, as taught by the claimed invention. On the contrary, the Carmeli reference explicitly states that the object of the invention is to test the performance of an electro-optical system with a "greater accuracy" than previously provided. (col. 3 ll. 16-18). Furthermore, if the Applicants follow the Carmeli reference, a single image of a blank textureless surface can not be used to recover intrinsic camera parameters.

Despite the Carmeli reference teaching away from the claim invention, the Applicants nevertheless realize the utility in estimating camera parameters, especially in applications which do not require accurate camera parameters, such as image based rendering applications. (See Specification, page. 3, lines 18-22).

Accordingly, from Carmeli's discussion of: 1) analyzing the output signal which is somewhat less than the input signal at its edges and corners (i.e., the fall off of the output signal) to evaluate the effect of vignetting, and 2) testing the performance of a camera with greater accuracy, the Carmeli reference does not and cannot describe approximating a vignetting effect and an off-axis pixel projection effect using a modeling equation. In fact, Carmeli teaches away from the claimed invention.

Similarly, the Applicants' claimed invention is distinct from the Stein reference because Stein too does not describe approximating a vignetting effect and an off-axis pixel projection effect. Stein merely describes using specialized patterns to recover intrinsic parameters of the camera. In fact, the Stein reference makes no mention of the vignetting effect or the pixel projection effect, let alone approximating them.

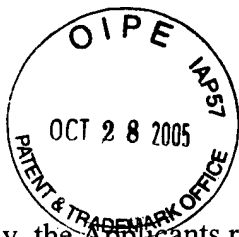
In this way, there is no suggestion or motivation to combine Carmeli, Stein and Applicants' specification page 1 when the combination does not describe or suggest all the claim limitations. The combination of Carmeli, Stein, and the so called, "applicant's admitted prior art" merely describes the use of specialized patterns to obtain intrinsic parameters, storing the obtained parameters into a database and then using the parameters stored in the database to test the performance of the camera.

The foregoing patentable distinctions are recited in independent Claims 1 and 6 with the following language or similar language:

"approximating the vignetting effect and the off-axis projection effect using a modeling equation."

Independent Claim 11 recites a similar distinction in terms of a computer system, while independent Claims 16 and 21 recite a similar distinction in terms of an apparatus. Accordingly, Claims 11, 16 and 21 are all patentably distinct over the references for the same reason. Similarly, independent Claims 46, 49 and 50 also include like limitations and are distinguishable over the references.

Claims 4-5 and 9-10 depend on independent Claims 1 and 6 respectively and thus include this limitation over the references. Claims depending on independent claims 11, 16 and 21 include this limitation over the references. Claims 47 and 48 depend on independent Claim 46 and thus follow. Claim 51 depends on independent Claim 50 and thus follows.



Accordingly, the Applicants respectfully submits that the claimed invention, as now amended, is not made obvious by the cited references or any references. The Applicants respectfully request the Office to remove the rejections under § 103(a) and allow Claims 1, 4-6, 9-11, 14-16, 19-21 and 25-51.

CONCLUSION

In view of the above amendments and remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By Mary Lou Wakimura
Mary Lou Wakimura
Registration No. 31,804
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133

Dated: 10/26/05